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PROPAGATION AND PRODUCTION OF WOODY ORNAMENTALS IN A SMALL NURSERY

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GLOSSARY

CALLUSING: Tissue that forms on a plant after a wound as part of the healing process.

CAMBIUM LAYER: The thin layer of tissue of a plant located between the bark (phloem) and the wood (xylem)

COLD FRAME: A structure built to provide protection for young plants. the sides are usually constructed from wood, with the lid of the frame of glass or plastic.

CONIFEROUS PLANTS: Plants with cones for reproductive structures. Leaves mostly needles or needle-like.

CROWN: That part of a plant at the surface of the ground where new shoots are produced. In single-stem trees, the crown is the portion of the tree from the point where branches originate on the tree trunk to the top of the tree.

DECIDUOUS PLANTS: Trees or shrubs that drop their leaves during the fall.

GARDEN CENTRE: A retail outlet generally dealing in a wide range of products for the garden.

GREEN MANURE: A crop that is seeded, allowed to grow then plowed under to provide organic matter to the soil. A legume crop such as alfalfa is often used to increase the amount of nitrogen in the soil.

HARDENING OFF: Involves restraining the growth of a plant resulting in the accumulation of carbohydrates which makes the plant better able to withstand adverse conditions. Hardening off can be accomplished by reducing water and/or temperature.

HEELING IN: Placing bare-rooted nursery plants close together in trenches with the roots well covered. This is a temporary provision for holding the young plants until they can be set out in their permanent location or marketed.

HERBICIDE: A chemical developed to kill plants.

INSECTICIDE: A chemical developed to kill insects.

LATHHOUSE: Structure built to provide protection from the sun for growing plants.

LIFTING: The process of harvesting nursery stock by digging the plants out of the ground.

LINER STOCK: Seedlings which are planted out then grown to a marketable-sized plant.

MICROCLIMATE: A climate that exists in a relatively small area, usually a modification caused by a land formation, shelterbelt, or a man-made structure.

NURSERY: An enterprise involved in the propagation and production of plant material.

pH: A symbol denoting the measure of acidity or alkalinity of a soil.

pH	3.0 - 5.0	strongly acid
	5.0 - 6.0	moderately acid
	6.0 - 6.5	slightly acid
	6.5 - 7.5	neutral
	7.5 - 8.0	slightly alkaline
	8.0 - 9.0	moderately alkaline
	9.0 - 11	strongly alkaline

ROOT PRUNING: The practice of reducing the size of roots by partial removal. Root pruning can be done on "lifted" planting stock with pruning shears. It is also applied to nursery stock located in the soil; cutting bars inserted vertically or horizontally around the plant will cut off the root structure and stimulate the development of new roots closer to the centre of the plants.

SCARIFICATION: The process of breaking, scratching, or mechanically altering the seed covering to make it permeable to water or gases. Scarification should not proceed to the point at which seeds are injured.

STRATIFICATION: "moist chilling" for after-ripening to break the dormancy of the seed. Conditions required to break dormancy include temperatures just above or slightly below freezing, intake of moisture by the seed, aeration, and a critical length of time for the changes to occur.

TREE FARM: A nursery involved in the production of large trees.

Introduction

This information is intended for the many people who have expressed interest in starting a nursery or tree farm. Some of these people might already be involved in running a landscape service, or they might have an interest in general farming. Other interested parties, however, lack experience with growing crops in general and tree culture in particular.

One feature these people have in common is that they own land, either an acreage or more. These landowners want to utilize this land as a tree farm or a nursery for purposes of growing woody ornamentals. They might approach this activity as an interesting hobby or they might be planning it as the start of a profitable business enterprise. Whatever a person's background or motivation, it should be clearly understood from the start that tree culture, or silviculture, is a specialized field.

The number of woody plants that can be grown in Alberta includes several hundred species and cultivars. Many of these plants are easily propagated (multiplied) either from seed or cuttings, while others require a detailed knowledge of seed treatment, grafting techniques and cultural management.

The successful nurseryman has to be familiar not only with the characteristics of the plants he grows, but he should know the soil and its suitability for tree growth, as well as the environment or climate which determines the potential growth of all plant life. Weed control after seeding and transplanting becomes the single-most costly management requirement; therefore the nursery operator has to be knowledgable about weed species and weed control methods. Although insect and disease problems are generally minor in a nursery operation, general knowledge about crop protection is essential.

Finally a nursery operator depends for his business on the goodwill of his clientele. He should know the market area, as well as the needs of such a market. The public comes to the nurseryman for advice about which species to plant; a good understanding of landscape design is a definite asset. Since nursery operators often specialize in the production of a limited number of species, the wholesale trade may be an integral part of the nursery enterprise.

With regard to seedling production, the small landowner has been kept in mind while assembling this information. A 5-acre plot could, with good management, produce half a million coniferous and deciduous seedlings on a yearly basis. Tree farms are usually larger and are dealt with briefly. The production of tree seedlings under a controlled environment (in the greenhouse) is considered to require a high capital investment and is not part of this booklet.

In the process of assembling this booklet, much information has been collected from existing handbooks and bulletins, as well as personal experience and direct observation. In the appendix a selection of the most useful and readily available publications has been listed. The prospective nurseryman, who is serious about becoming successful in developing a nursery, will have to educate himself through study of a wide variety of materials and experiment on his own. Operating a nursery is a fascinating business. Each day brings different problems, pleasures and satisfactions.

Good luck to you and your business.

SELECTION OF THE NURSERY SITE

Careful selection of the nursery site is fundamental to the success of a nursery operation. The quality and cost of stock is largely determined by the suitability of the site for propagating and growing plants. Retail nurseries should be readily accessible by the customers and close to a concentration of population. On the other hand, wholesale nurseries are not dependent on close proximity to the market.

In the introduction it was pointed out that much interest in tree production has been and is being expressed by acreage holders and/or hobby farmers. The comment was made that people who own land want to use it for production of woody ornamentals. The acreage holder is limited by the quality of land owned, this fact must be fully understood before beginning a nursery. Usually such land was not chosen primarily because of its suitability as a tree and shrub nursery. On the other hand large areas of the province of Alberta were at one time covered with trees. Therefore, trees will grow and can be cultivated almost anywhere in this province. However, as prospective nursery operators, we are interested in making tree culture our business and are interested in optimum growth conditions.

WHAT ARE PREFERRED GROWING SITES?

A. Soil

Light textured soils are best. These are classified as sandy soils, loamy sands or sandy loams. Well drained sandy loams are particularly desirable. These soils have the advantage in ease of working, quickly drain after wet periods, and tree root systems can readily penetrate the soil stratum. At time of harvest, roots will be damaged less in a loose structured sandy loam. Sandy loam soils make good seedbeds because the surface does not cake or crust.

Heavy clay soils are much less desirable for nursery seedling production. Such soils cannot be worked during wet spells and it takes too

much time after a heavy downpour for clay soils to dry out again. In such soils roots tend to be damaged more during lifting, particularly when the soil is dry and packed hard. On the other hand, clay soils, particularly the deep black clays, are good for tree farming. The moisture retaining capacity of black clay soils is high, which is an advantage for growing large trees.

Organic or peat soils are attractive from the standpoint of moisture retaining capacity and ease of working. However such soils often become soggy during wet periods, such as spring run-off. Fertility levels are low and the soil is acid (low pH). Typical Grey Wooded soils are low in organic matter and tend to form a surface crust. For these reasons organic soils and Grey Wooded soils are only suitable for tree farming but are not recommended for seedling production.

Soils with a high salt content close to the surface (saline soils), and soils with a compacted sublayer (such as solonetzic soils) are not suitable for tree production.

Soil preparation

The nursery site should be prepared well in advance of sowing and transplanting. Several of the following items may require attention, although not necessarily in this order:

1. Eradicate perennial grasses and weeds such as quack grass, dandelions and thistles by cropping, repeated cultivation, or by use of suitable weed control chemicals that do not persist in the soil.

2. Level or smooth soil irregularities and remove trash or surface stone. This is also the time for grading and ditching to improve overall drainage. In nurseries some surface drainage is often provided by raised seedbeds, but for this to be effective the paths between beds must drain evenly to a ditch system.

3. It might be necessary to improve very light or too heavy soils with organic matter (peat moss). Organic matter should be rototilled in to a depth of at least eight inches. Another means of improving soil structure is through the use of green manures such as clover and alfalfa. Soil sampling to determine pH and nutrient levels should be carried out prior to seeding and planting activities. It might be advisable to improve the pH and/or soil structure with a lime application.

Further details regarding soil type, soil sampling kits and soil sampling services can be obtained from the Soils Branch of Alberta Agriculture, 9718 - 107 Street, Edmonton, T5K 2C8.

B. CLIMATE

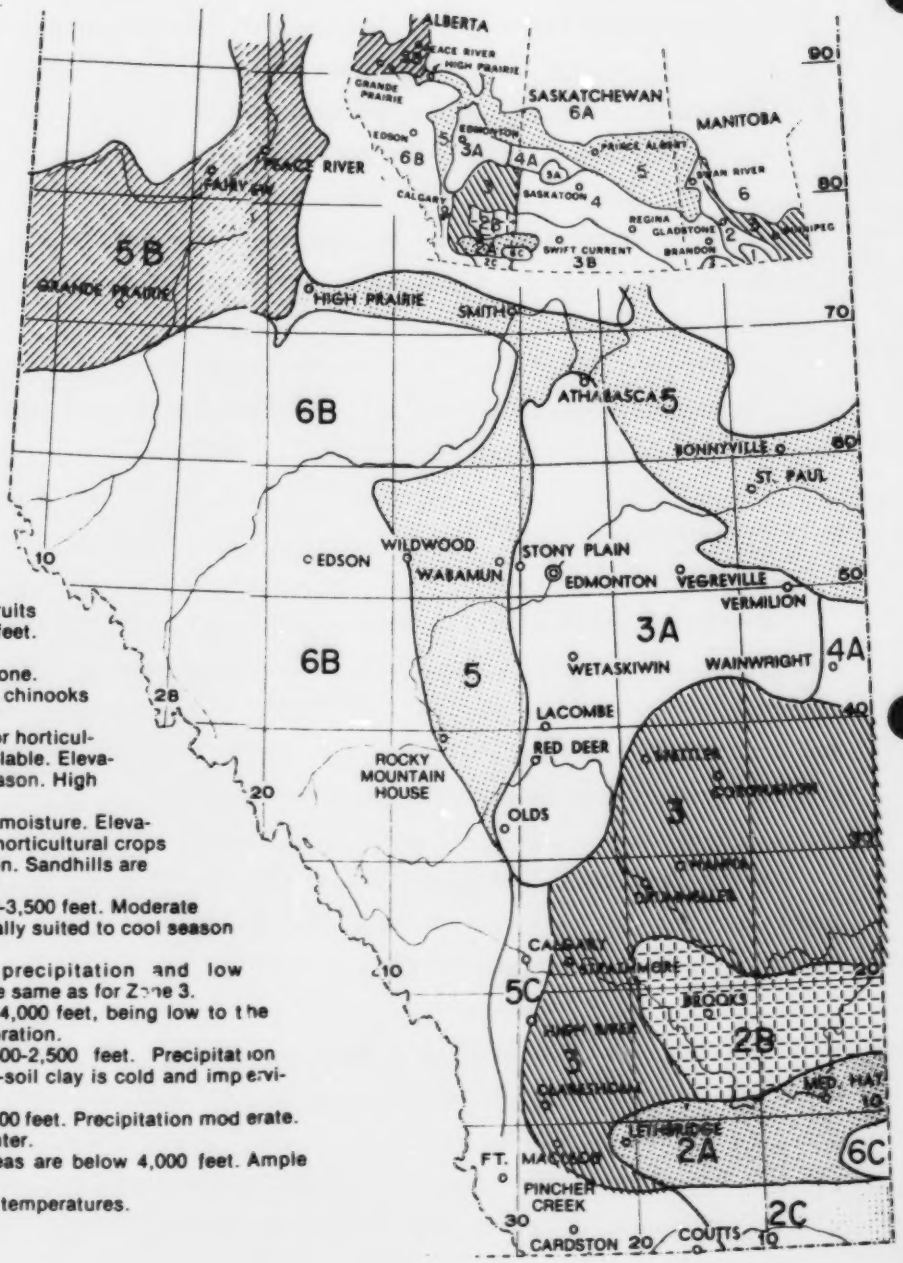
The Province of Alberta spans a number of horticultural climatic zones (see map on following page). These zones are decided on the basis of length of frost-free period, elevation, precipitation, evaporation, and occurrence of chinook winds. These are the major environmental factors that affect the growing of trees and shrubs.

It is difficult to pick out one of these factors as the most important, as the variation through the province is quite large, and the factors are closely interrelated.

The length of the growing season limits the varieties that can be produced successfully. This is especially evident in zones 5 & 6, where the growing season may be as short as 60-90 days. Other areas, such as zones 2 & 3, have a much longer growing season, but lower rainfall and greater exposure to the elements place additional limitations on growing nursery stock.

Alberta

HORTICULTURAL ZONES in ALBERTA



The Western Provinces are divided into six horticultural zones, some of which are subdivided. The Alberta zones designated on the map, are described as follows:

2A 125-155 days frost-free period (-1°C.). It is subject to severe chinooks, and fruits require shelter. Elevation 2,000-3,000 feet. High evaporation.

2B 120-130 days (-1°C.). Extremely dry zone. Elevation, 2,000-2,400 feet. Subject to chinooks and high evaporation.

2C 100-120 days (-1°C.). Ideally suited for horticulture when supplementary water is available. Elevation, 3,000-3,500 feet. Hot growing season. High evaporation.

3 100-110 days (-1°C.). Zone of limited moisture. Elevation, 2,000-2,400 feet. Suitable for all horticultural crops in selected areas. Moderate evaporation. Sandhills are similar to Zone 5.

3A 100-120 days (-1°C.). Elevation, 2,000-3,500 feet. Moderate precipitation and low evaporation. Ideally suited to cool season crops.

4A 100-110 days (-1°C.). Variable precipitation and low evaporation. Recommendations are the same as for Zone 3.

5 90-100 days (-1°C.). Elevation, 2,400-4,000 feet, being low to the north. Variable precipitation and evaporation.

5B 90-100 days (-1°C.). Elevation, 1,500-2,500 feet. Precipitation moderate but water table low and sub-soil clay is cold and impervious, and growth often slow.

5C 60-90 days (-1°C.). Elevation, 2,400-4,000 feet. Precipitation moderate. Subject to severe chinook winds in winter.

6B 90-110 days (-1°C.). The suitable areas are below 4,000 feet. Ample moisture, low evaporation.

6C Similar to 6B, but with higher summer temperatures.

The length of the growing season limits the production of trees and shrubs in several ways. If the season is too short for maturation (hardening off) of the new growth, the plant will suffer from winter injury. This injury may be tip killing, where a few inches of the previous season's growth is killed off, or it may be so severe that the plant will winterkill to ground level.

Even certain trees and shrubs that are capable of hardening off within the growing season may be injured by extremely cold temperatures in the winter. Plants that are well hardened off can normally withstand temperatures within the range of 0 to minus 25^{o}C. Temperatures below this may affect some species, injuring flower buds and roots. With these species continuous snow cover is important. Often times, the only portions that survive with healthy buds and roots are those below the snow line.

Temperature fluctuations can cause severe injury to trees and shrubs. Rapid changes in temperature are especially noticeable in the areas of the province where chinooks occur often (Zones 2A, 2B, 5C). Rapid thawing followed by freezing causes some of the tissue cells to rupture. This can result in frost cracks on stems, leading to a drying out of the cambium layer and wounds through which disease and insects can enter.

Strong winds in both winter and summer can affect normal tree growth. In the winter particularly, wind can cause dessication of tissue, because water uptake through the roots is minimal. Evergreens are especially susceptible to this type of damage. Strong winds in summer can also cause dessication. Planting a shelterbelt on the north and west sides of the nursery can help to alleviate these problems.

In areas of low precipitation and high evaporation (zones 2A, 2B, 2C and 3), moisture may be a limiting factor in nursery production. The natural precipitation may need to be supplemented by irrigation. Evaporation can be curtailed by planting a shelterbelt. This cuts down the speed of the drying winds, and the trees and shrubs are protected from dessication.

It is very important to consider the climate of the area where a nursery is being established. Modifications can be made to provide a more suitable "microclimate" for the nursery e.g. irrigation systems, and shelterbelts. It should be remembered that only trees and shrubs suitable for our climate should be grown and offered for sale. Trying to establish a nursery business by selling stock that is not hardy is unethical and, in the long run, unprofitable.

A shelterbelt around nursery grounds is recommended.

TREE AND SHRUB VARIETIES

The number of varieties of woody ornamentals which can be cultivated in Alberta is limited compared to regions with milder and more humid climates. There are two readily available publications which contain listings of woody plants of proven value for use as landscape material:

1. *The Alberta Horticultural Guide* by Alberta Agriculture
2. *Woody Ornamentals for the Prairie Provinces* by R. H. Knowles

Around 60 genera of woody plants representing well over 250 species are listed in these two publications. (For further details about publications consult the list of recommended literature on page 64.)

Although all of these woody plants are used for landscape purposes and consequently require propagation and cultivation, not all varieties are recommended to the inexperienced nurseryman as possible crops. Several good reasons can be given:

The more outstanding horticultural varieties, called "cultivars" were developed by choosing an outstanding representative of the variety. This one plant may have outstanding merit with regard to particular features such as form or shape, color of foliage, hardiness, flower display or a combination of such features. These plants are as a rule, propagated vegetatively by cutting, layering or grafting. Such propagation requires a greenhouse with a misting system.

Cultivars propagated from seed will in general lose their outstanding characteristics and become typical representatives of the plant variety. The following is a list of woody plants recommended for propagating by the inexperienced or hobby nurseryman.

WOODY ORNAMENTALS RECOMMENDED FOR PROPAGATION

TYPE	SCIENTIFIC VARIETY NAME	COMMON NAME	AVERAGE DATE FOR SEED HARVESTING	METHODS FOR PROPAGATION	RECOMMENDED TIME FOR SEEDING PLANTS
Coniferous Evergreen (Tall)	Abies balsamae	Balsam fir	Cones ripen by the end of August.	Seed	Fall
	Picea glauca	White spruce		Seed	Fall
	Picea pungens	Colorado spruce		Seed	Fall
	Pinus cembra	Swiss Stone pine		Seed	Fall
	Pinus contorta latifolia	Lodgepole pine	Closed cones can be harvested any time.	Seed	Fall
	Pinus sylvestris	Scots pine	End of August	Seed	Fall
	Pseudotsuga menziesii	Douglas fir	End of August	Seed	Fall
Coniferous Evergreen (Dwarf)	Pinus mugo pumilio	Dwarf mugo pine	End of August	Seed	Fall
	Juniperus scopulorum	Rocky mountain juniper	September	Seed	Fall
	Juniperus horizontalis	Ground juniper	September	Seed	Fall
Broadleaf Evergreen (Ground cover)	Arctostaphylos uva ursi	Bearberry, Kinnickinnick		Subdividing vegetatively	
	Euonymus nana	Dwarf burning bush		Seed	
	Vinca minor	Periwinkle		Runners	
Deciduous (Tall)	Acer negundo	Manitoba maple	Mid September	Seed	Spring
	Aesculus glabra	Ohio buckeye	Mid September	Seed	Fall
	Betula papyrifera	Paper birch	August - September	Seed	Fall
	Crataegus	Hawthorn	September	Seed	Fall
	Elaeagnus angustifolia	Russian olive	September	Seed	Fall
	Fraxinus	Ash	October	Seed	Fall
	Larix	Larch	August	Seed	Fall

TYPE	SCIENTIFIC VARIETY NAME	COMMON NAME	AVERAGE DATE FOR SEED HARVESTING	METHODS OF PROPAGATION	RECOMMENDED TIME OF SEEDING PLANTS
	Populus	Poplar		Hardwood cuttings	May
	Prunus padus	Mayday	Early September	Seed	
	Prunus pennsylvanica	Pincherry	Early September	Seed	Fall
	Prunus virginiana	Chokecherry	Early September	Seed	
	Quercus	Bur oak	Early September	Seed	Fall
	Salix	Willow		Hardwood cuttings	
	Sorbus	Mountain ash	August	Seed	Fall
Deciduous (Small trees and shrubs)	Acer ginnala	Amur maple	September	Seed	Fall
	Amelanchier	Saskatoon	August	Seed	Fall
				Suckers	
	Caragana	Caragana	August	Seed	Fall
	Cornus	Dogwood	August	Seed	Fall
	Cotoneaster	Cotoneaster	August	Seed	Fall
	Hippophae rhamnoides	Sea buckthorn	September	Seed	Fall
	Lonicera	Honeysuckle	August	Seed	Fall
	Prinsepia	Cherry prinsepia	August	Seed	Fall
	Prunus besseyi	Western sandcherry	August	Seed	Fall
	Prunus tomentosa	Nanking Cherry	August	Seed	Fall
	Prunus japonica	Chinese bushcherry	August	Seed	Fall
	Rosa "Altaica"	Altai rose	September	Seed	Fall
	Salix	Arctic willow		Cuttings	Spring
	Sambucus	Elderberry	August	Seed	Fall
	Shepherdia argentea	Silver buffaloberry	August	Seed	Fall
	Syringa	Common lilac	August	Seed	Fall
		Villosa lilac	August	Seed	Fall
	Viburnum trilobum	Highbush cranberry	August	Seed	Fall
	Viburnum lentago	Nannyberry	August	Seed	Fall

The foregoing table lists the scientific names of the plants. The following remarks are taken from the "Catalogue and Common Names of Woody Ornamentals" by R. H. Vick, a publication of the Devonian Botanic Garden of the University of Alberta. See bibliography Page 64.

THOSE CONFUSING PLANT NAMES

Have you ever bought a "Rose Tree of China" and discovered later that it's the same thing as your double flowering plum? Or purchased a red-leaved cherry from one supplier, and a purple-leaf plum from another, to discover that they are both the same as your cistena cherry that just winter killed? You are not alone.

These little annoyances occur year after year to countless people who believe, in all innocence, that one kind of plant should have one name, and that one name should apply to only one plant. Unfortunately this is not the case, and plant catalogues continue to include a varied selection of common names, some from Britain, some translations of continental European names, and some imported with plants from south of the Canadian border.

Many plant lists and catalogues now include the supposedly stable botanical name, and while this is a great help, even some of these are subject to revision. Betula pendula "Gracilis" and Betula verrucosa "Gracilis" are both the same CUTLEAF WEEPING BIRCH. To add another element of confusion, some cultivated varieties (cultivars) have pseudo-botanical names, such as Cornus elegantissima with is really... but let's not get into that here. The point is that this lack of standarization, particularly with regard to plant common names, is a cause of considerable irritation and confusion."

Nursery operators should make every attempt to familiarize themselves with the Latin names of the stock they are growing and selling. It may alleviate future problems and confusion if their business is conducted using the scientific Latin name.

PROPAGATION

SEXUAL PROPAGATION

The growing of plants from seed is something from which people of all ages obtain a good deal of enjoyment. From the very start, satisfaction is experienced as germination of the seed and the early growth of the seedling are observed. It is very disconcerting, however, to plant seeds, give them what we consider ideal conditions for germination, and fail to get results. This happens frequently when trying to grow trees and shrubs from seed.

The seeds of woody plants fall into two broad classes:

- Those which germinate immediately following the ripening of the fruit, eg. elm, Manitoba maple etc.
- Those which fail to germinate when extracted from the ripe fruit, eg. rose, apple, plum etc.

The failure of seeds belonging to this second group to germinate when exposed to what the flower and vegetable grower might consider normal germinating conditions is due to a need for after ripening, or a "stratification" period.

The production of plant material from seeds follows a definite sequence:

1. Germination of the seed
2. Vegetative growth
3. Flower induction
4. Flower initiation and development
5. Enlargement and opening of the flower, pollination, fertilization
6. Fruit and seed development
7. Ripening of the fruit and dissemination of the seeds

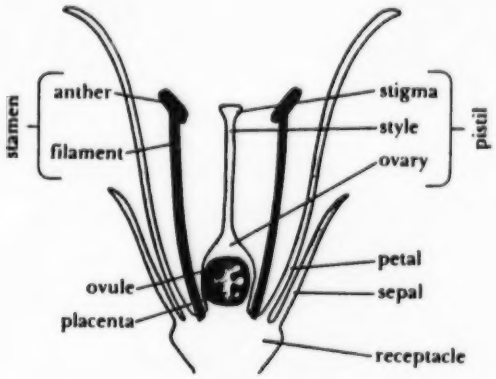
Seed plants (spermatophytes) are divided into two main groups:

Gymnosperms - these are the conifers; they have naked seeds borne usually in cones.

Angiosperms - these are the true flowering plants: they have their seeds enclosed in a fruit.

For our purposes, the young cones of gymnosperms are considered as flowers.

Structure of a Flower

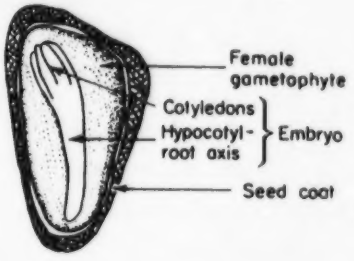


In some trees/shrubs, one or more parts are lacking, e.g. the willows lack the calyx and corolla; birch lack either stamens or pistils, depending on sex. In other species all the floral parts are present, but instead of being separate, they are more or less united, e.g. petals are united in honeysuckles.

Flowers vary considerably in size, shape, and number of parts. The most important parts with respect to seed production are the pistils and stamens. The pistil produces the egg within the ovary; the stamen produces the pollen which must first reach the pistil and travel down to the ovary where the egg is fertilized by a sperm cell produced in the pollen grain; a seed results. The other parts of the flower act in supporting roles; the calyx and corolla protect the delicate stamens and pistils; in addition, some parts attract insects by their smell, color, or nectar supply which aids in pollination. Where the calyx and corolla are absent the flower is pollinated by wind, or both pistil and stamen are found within the same flower structure.

Cones of conifers lack the calyx, corolla, stamens and pistil on the same flower structure. The male and female elements are borne in separate cones. The male flowers or staminate cones of most conifers are small, yellowish, numerous, and short lived. They produce the pollen grains which are carried long distances by the wind. The female flowers, or ovulate cones, are fewer in number, usually small, having scales bearing naked ovules which develop into seeds.

Once the pollen is attached to the stigma of the pistil it germinates and a tube is pushed down the style until it reaches the embryo sac. Male cells (gametes) from the pollen tube unite with female gametes in the sac, and fertilization takes place to produce the embryo and endosperm. To produce viable seed, both pollination and fertilization must take place. As shown by the fluctuation of cone crops, in spruce particularly, there are years when because of external forces eg. frost, insect damage, etc. no male and/or female cones are produced. In addition, the pollen may not ripen sufficiently or may dry on the stamen without being released.



FIR

Once fertilized the embryo cells divide until an embryo is produced.

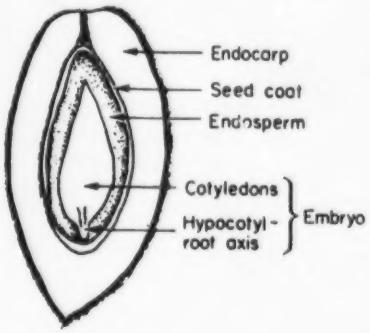
Specific physical and chemical changes take place during ripening which lead to the aging of the fruit and the dissemination of the seed. One obvious change is the drying of the fleshy part of the fruit. An early indication of seed maturity is the color change which takes place in the fruit.

The seed of the angiosperm is a matured ovule enclosed within the ovary or fruit. So in most instances we use the matured ovule when we seed.

There are three main parts to a mature seed -

- Embryo - that part which contains all of the genetic material to produce a plant.
- Food storage tissue - this is material which holds food for initial growth; it is used until the root can start taking up nutrients and the plant can manufacture its own food.
- Seed covering - this is protective material which prevents injury to the embryo.

The embryo or germ is composed of seed leaves called cotyledons, the bud or plumule, stem or hypocotyl and rudimentary root or radical: a plant in miniature.



OLIVE

Collecting Seed

Determining the time of collection is difficult, as there are many factors affecting seed maturity. In some species it is very easy to tell when the seed is mature, e.g. caragana is mature and should be picked just as the pod begins to turn brown.

Collecting fruit of the mayday, the hawthorn, chokecherry, etc., at specific times will result in different germination rates because of inhibitory chemicals produced by the flesh.

STORING SEED

The seeds of each species of tree and shrub require different treatment in order to keep the embryo viable. More detailed information can be obtained from "Plant Propagation" by Hartmann and Kester or "Woody Plant Seed Manual" available from the U.S. Department of Agriculture, miscellaneous publication No. 654. (See publication list)

The storage conditions that maintain seed viability are those which slow respiration and other processes without injuring the embryo. To achieve this result three conditions must be met.

1. Moisture content of the seed - seeds require a definite amount of moisture to maintain life. A moisture content of less than 10% is desirable. Seed of trembling aspen must be dried very well and stored under extremely dry conditions at $0^{o}C$.

2. Storage temperature - on the whole, seeds must be stored at low temperatures in order to decrease cellular activity within the embryo. Deciduous material is best stored at $0^{o}C$ to $-4^{o}C$, coniferous seed is stored at $-18^{o}C$.

3. Storage atmosphere - the atmosphere around the seed can be changed in a variety of ways to increase the life of the short-lived embryos. Certain seeds may require a high CO_2 level.

It is important that effort be made to dry seeds of some species before storage and to prevent others from becoming too dry during storage. Storing seed in moisture-proof containers is probably the best way of regulating the moisture content of the seed.

DORMANCY

All tree and shrub seeds show some degree of inherent dormancy. Dormancy is the term used to define the inability of the seed to germinate

even when the required conditions are given. This inhibition must be broken in order to have germination happen when required.

Each species of plant material has a particular treatment required to break dormancy. Treatments to break dormancy usually involve methods of breaking the seed coat. Some treatments are required to break down chemical inhibitors affecting the embryo. Severe dormancy is usually found in species that have a fleshy seed covering which produces chemicals that prevent the seed coat from breaking down and permitting water uptake.

It has been shown that during after-ripening the stored food of the seed is broken down into a form which may be utilized by the mature or developing embryo. In most cases, these changes take place in a moist, well-aerated medium at a critical low temperature. One should not expect the seeds to respond immediately to these conditions; changes in stored food take place very slowly and many seeds may take sixty days or more to give the first indication of germination.

Another factor which often complicates after-ripening is the nature of the seed coat. In many cases, this covering is so hard that it offers mechanical resistance to rupturing; in others, it is so impermeable to air and moisture that after-ripening is suspended entirely. Under natural conditions, the mechanical and physiological resistance of the seed coat is overcome by the action of soil micro-organisms and other weathering agents, and frequently by passage of the seed through the intestines of an animal or bird. In the home laboratory, however, one must resort to other methods of overcoming this resistance before undertaking after-ripening procedures.

In spite of these difficulties, one should not be discouraged from trying to grow woody plants from seed. The challenge presented should only serve to heighten the interest normally associated with germination.

In general, there are two main types of dormancy, a description of each plus the appropriate treatment follows.

1. External Dormancy

This condition is caused by an impenetrable seedcoat. Dormancy can often be broken by treating the seedcoat in one of the following ways.

a. Acid Treatment

This treatment involves the soaking of seed in concentrated sulfuric acid. The time required varies from species to species but is usually from 15 to 60 minutes. As the seedcoat is dissolved by the acid, one must be careful not to expose the embryo to the acid or it will be killed, therefore the acid must be removed from the seedcoat before it reaches the embryo. Acid treatment is becoming less popular due to damage done to the seed embryo.

Juniper, a resinous seed, is generally made permeable by soaking in a weak solution of lye for twenty minutes, followed by washing in fresh water and soaking in water for another 8 hours prior to stratification.

b. Mechanical Scarification

This treatment involves the scratching of the seedcoat with an abrasive. Tumbling or churning the seed over sandpaper or in a mixer with coarse sand or gravel are common methods used.

Plums and other stone fruits will respond to cracking of the seedcoat with pliers, however, most growers find this procedure too time consuming and either stratify directly or place the seeds in soil at room temperature for a certain critical length of time to allow the soil bacteria to work on the seedcoats before [illegible] temperature stratification.

c. Soaking

This treatment involves the soaking of seed (e.g. legumes) in very hot water 77 to 100°C (170 to 212°F) for up to 12 hours.

2. Internal Dormancy

This dormancy is caused by chemical action on the embryo, preventing its growth. To break this type of dormancy the following methods are used:

a. Cold stratification

This involves exposing the seed to sufficient moisture and adequate oxygen at a temperature between 0^{o} and $5^{o}C$ (31 and $41^{o}F$) for one to four months.

b. Warm/Cold Stratification

This treatment is usually required for seeds of species which mature in the spring. The seed is exposed to warm summer temperatures then cold winter temperatures, followed by spring germination. This involves a temperature of 20-$30^{o}C$ (68-$86^{o}F$) for one to several months, then storage at $5^{o}C$ ($41^{o}F$) for one or more months.

c. Chemical Treatment

Experimental work is going on in Europe and North America using such material as thiourea and ethylene chlorhydrin to break down internal chemical dormancy.

See to Table I in the appendix "Stratification".

One must always be aware of the following when seeding tree and shrub species.

- Percent Germination

A trial to determine the percentage of the seed one can expect to germinate should be done before seeding. Usually a sample of 300 seeds is taken, optimum conditions are given the seeds and the number germinating is counted after a specific number of days.

Elaborate means are available, including the use of X-rays, to determine the percent of viable seed in a sample.

- Percent Purity

This is a figure used to show the amount of extraneous material (inert material) and the number of weed and other seeds contained in a pound of seed.

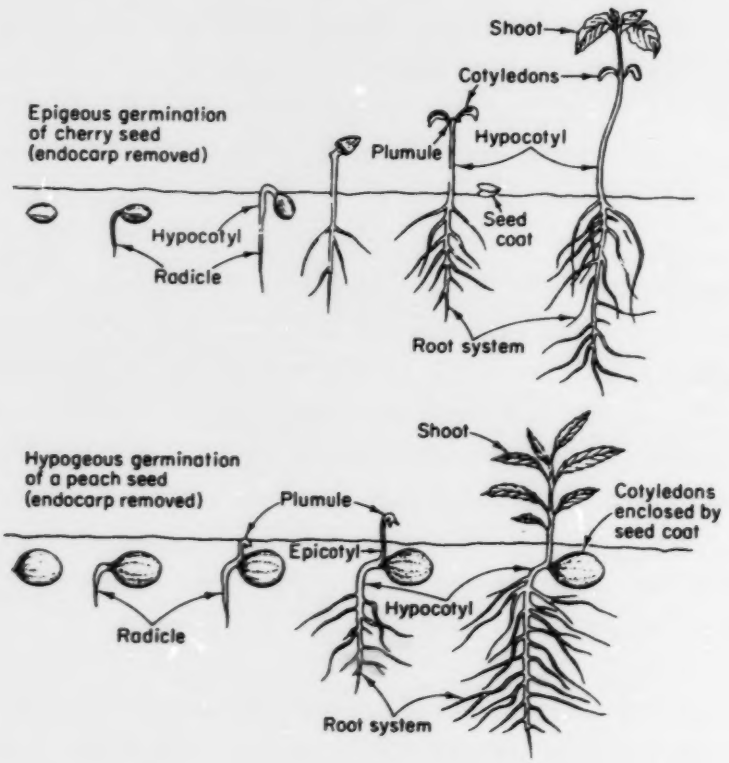
Moisture Content

This is required only if seed is to be stored, as most embryos will deteriorate if moisture within the seed is above 10%.

GERMINATION

From the embryo and through use of stored food we can produce a new plant.

The emergence of a seedling and its development to the point it can maintain life is called germination.



In order for a seed to germinate three conditions are necessary.

1. The seed must be capable of germination - it must be viable.
2. The seed must be ready to germinate.
3. The external conditions must be favorable for germination.

The process of germination occurs in five steps.

1. Uptake of water: all seeds, viable or not, absorb water; water softens the seed coat, and provides water to the protoplasm or the living material of a cell. Water is one of the necessary ingredients in energy conversion.

2. Initiation of cell activity; the emergence of the radicle or root is the first visible sign of germination.

3. The stored food is digested by the growing embryo.

4. The conversion of the stored food into energy required for cell activity and growth.

5. The embryonic seedling grows by division, enlargement and differentiation of cells at the growing points.

GERMINATION REQUIREMENTS

1. Moisture

The cells of the seed cannot carry on vital processes without water. Water requirements differ for each genus of plant.

It has been shown that some pine seedlings require 172 percent of the moisture found in dry seed, or 23 times as much.

The rate of water uptake is largely dependent upon the degree of seedcoat permeability. Scots pine seed will absorb 35 - 37% of the water it needs in 48 hours, other seeds require 18 or 20 days to absorb the required water (e.g. yew).

A constant supply of water is a must, germinating seeds should never be allowed to become dry. Overwatering is almost as bad, the seed bed must be kept moist but not water logged.

2. Temperature

Some seeds will germinate well under a wide range of temperatures, others require a narrow temperature range.

3. Oxygen

Oxygen is necessary for the process of respiration, which is the oxidation of sugars. Seeds will not germinate if the supply of oxygen is inadequate.

4. Light

There is a differing need for light by germinating seeds. Some seeds will not germinate with light, others require it. The particular species you are working with will determine light requirements. Most commonly used species have either a low light requirement or none at all. Refer to Table II "Germination" in appendix.

CARE OF SEEDLINGS

Newly germinated tree and shrub seedlings require a certain amount of special care before they are able to grow effectively in the open. Thus, in order to protect them from the effect of strong sun, high temperature and wind, it is advisable to plant the seedlings within the shelter of a frame for the first year. No special construction is required as long as the structure will support a lath shade to protect the plants during the summer. Soil must be friable and if too "heavy" may be lightened by the addition of sand or peat.

DAMPING-OFF

Damping-off is one of the first diseases the nurseryman encounters in his newly-sown beds.

Damping off is widespread in nurseries throughout North America. Most conifers are susceptible, with the notable exception of the junipers. Among the hardwoods, American and Siberian elm and Russian olive are very susceptible. Green ash and bur oak have considerable resistance.

Symptoms vary, depending on when infection occurs. Early attacks on the developing radicle may kill the seedling before it emerges from the soil.

Damping off may be controlled by cultural or chemical means. Losses have generally been reduced by practices that increase the rate and uniformity of germination and the speed at which the seedlings grow in early weeks. Regulation of soil moisture may reduce losses from certain fungi.

The seed-protectant fungicide thiram is sometimes effective, if inconsistent, in reducing losses in conifer beds. If temperatures are high, fungicides may reduce the amount and speed of germination.

Soil treatment prior to sowing is feasible. Applying inorganic acids to reduce pH has been useful on soils with a pH range from 6 to 8. Drenching soil with the fungicide captan is also effective, but once symptoms become evident it is usually too late to drench.

For additional information on diseases, please consult the literature list of this publication.

Once the seedlings have had a year in the frame, they may be transplanted to the nursery row, or if space is at a premium, to a permanent location. It should be kept in mind, however, that transplanting, no matter how carefully done, is damaging to the root system of the plant, and some pruning of the top, in the case of deciduous plants, should be done in order to retain a desirable shoot balance. Since it is more difficult

to top-prune evergreens without spoiling the form of the plant, particular care should be exercised at the time of transplanting to retain as much of the fibrous part of the root system as possible.

VEGETATIVE PROPAGATION

Vegetative propagation is reproduction from a portion of the growing plant such as the stem, root, or bud. These portions of many plants are capable of regenerating a new plant genetically identical to the mother plant the portion was taken from.

Vegetative propagation is used to produce trees and shrubs for several reasons. Woody material with desirable characteristics that may be lost through seed propagation is often produced in this way. Most fruit varieties and hybrids are propagated vegetatively to perpetuate the lines. Many species are produced most efficiently vegetatively; the ease and speed of vegetative propagation far excells the use of seeds. Vegetative propagation is of three main types; rooted cuttings, layering, and grafting. The method chosen is governed by the objectives of propagation, the species being propagated, and the age and vigor of the tree or shrub being propagated.

1. CUTTINGS

This is the most widely used method of propagating ornamental plant material vegetatively. It is relatively inexpensive and quick, and does not require the technical skill involved in grafting. When dealing with trees and shrubs we mainly use stem cuttings. The kind of stem cutting used depends on the nature of the wood used in making the cutting.

a. Softwood cuttings - These are cuttings of the current season's growth taken in late spring or early summer. The cuttings are made after the leaves appear and are fully developed. Softwood cuttings generally root easier and quicker than other types of cutting but require more attention and equipment. It is necessary to have a propagation area with bottom heating supplied such as a heated mist

tent or hot bed.

b. Semi-hardwood cuttings - These are taken in the summer from the new growth that is fully developed and partially mature. The cuttings are three to six inches long with leaves removed only from the bottom of the cutting. These cuttings must be placed in a specialized propagation area where bottom heat is supplied and high humidity can be maintained.

These methods demand specialized equipment for successful propagation. For more information, refer to the publications list for literature on propagation.

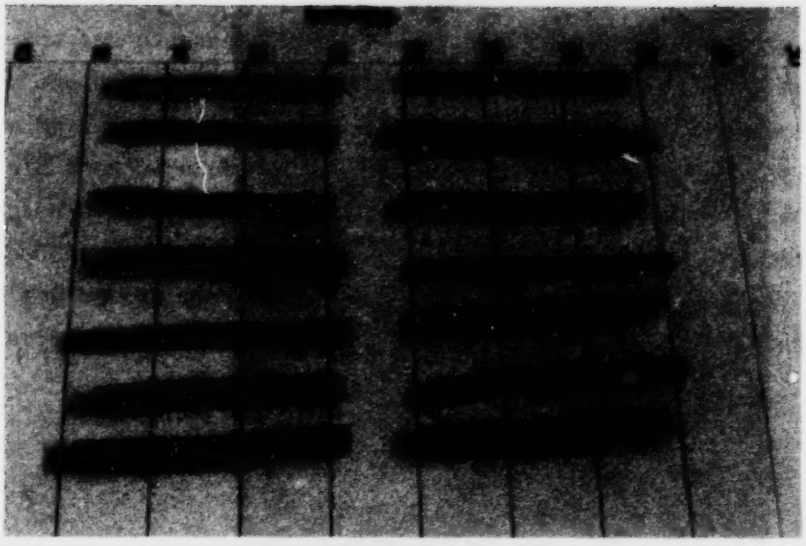
c. Hardwood or dormant wood cuttings - These are the most widely used cuttings and the ones the remainder of this section will deal with.

i. Season - The cuttings are taken during the dormant season - late fall, winter, or early spring - any time between leaf drop and the start of new growth. Late fall, after a good frost, or early spring are a preferable times for taking hardwood cuttings. The cuttings should be taken from healthy, vigorous stock. The wood for the cutting is the current season's growth, if taken in fall or winter, or the previous year's growth if taken in the spring.

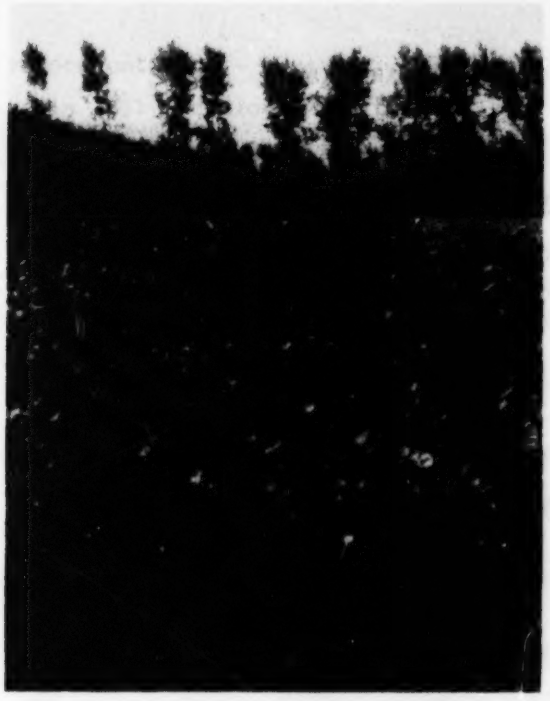
ii. Size - Individual cuttings are from six to ten inches long. The bottom cut is done below a node with the top cut about 1 cm above a well-developed bud. The ideal thickness of a cutting is pencil size. Any cutting smaller than this should be discarded.

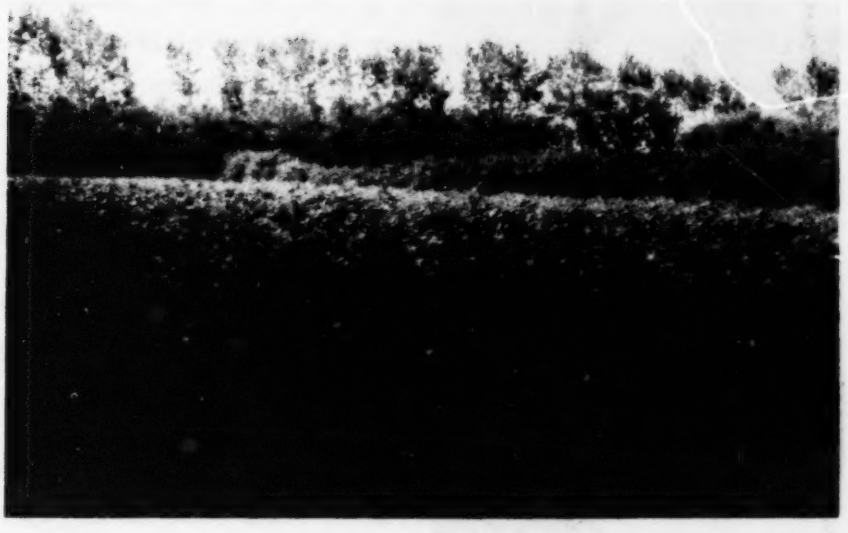
iii. Storage - The cuttings should be put into convenient sized bundles. They are packed with the butt ends up to encourage callusing. Sand, peat moss, or moist soil should be packed firmly around the cutting. The cutting must be protected from drying out, excessive freezing, and exposure to high temperatures. The cuttings are placed in a pit dug outside in a spot where snow will cover the ground all winter. If this is not possible the packaged cutting should be stored in a root cellar or cool basement. Ideal storage temperatures are between 0 to 4.5^{o}C. If possible, the cuttings should be examined occasionally to make sure they haven't dried out.

HARDWOOD
CUTTINGS



A ONE-YEAR-OLD
ROOTED CUTTING





Griffin poplar from cuttings made from November to January planted in June, photos show growth in August the same year. Water requirement of cuttings is very high for the first 6 weeks.

iv. Planting - In the spring after the ground has warmed up the cuttings should be planted out. They can be planted either in the desired permanent location or, preferably, in a nursery bed. The cuttings should be placed in rows 20-40 cm apart, 2-4 cm apart in the row and planted deep enough so that 3/4 of the cutting is buried, with one or two buds above the ground. They can be planted in a furrow made by a cultivator, set in along the side of the furrow. The furrow should then be closed and packed firmly. The cuttings can also be planted by making a hole or slit with a shovel large and deep enough to accomodate the cutting. The cutting is then placed in the hole, with the top of the cutting buried just below the soil surface. After planting these cuttings should be well watered until sprouting starts.

Hardwood cuttings being machine planted

v. Transplanting - If the cuttings are placed in a nursery bed they should be dug and moved by the next spring. If left in the ground longer, particularly with poplars and willows, they may become too large and the root systems too extensive to move easily.

2. Layering

This method of vegetative propagation involves development of roots on a stem while it is still attached to the parent plant. After the roots have developed the rooted stem is cut from the parent plant and transplanted. Layered stems produce roots more successfully than stem cuttings because the stem continues to receive moisture and nutrients from the parent plant. If only a small number of plants is needed, layering of some species is easier than rooting cuttings because it requires less effort and equipment. Layering is not generally used for large scale production, but for those plants in which layering occurs naturally, it is a simple and economical method of propagation. This includes currant, dogwood, and creeping juniper.

Simple layering is done by bending a branch to the ground and covering it with three to six inches of soil, leaving the terminal end exposed. A sharp bend that causes the terminal end to stand upright may help induce rooting past the point where the bend is made; wounding the bark at this point will promote root forming. Layering is usually done in the early spring with dormant one-year-old shoots. Shoots layered in the spring will usually have developed adequate root systems by the next season and can be transplanted in early spring before growth starts.

3. Suckers

A sucker is a shoot that grows from the below-ground portions of the plant. These are normally developed from an adventitious bud on a root but may also develop from the crown of the plant. A sucker is a complete plant in itself although it is still attached to the root of the parent plant. Suckering occurs with woody plants such as the saskatoon, lilac and raspberry. Suckers are dug out and cut from the

parent plant. If there is a tight clump of suckers the entire clump should be dug up and then separated into individual plants. When suckers are located individually and away from the parent plant they are dug about six to ten inches from the sucker and between it and the parent plant. Digging the sucker should be done in early spring before any new growth starts.

4. Grafting

This technique of propagation involves joining parts of plants together so they unite and grow as one plant. The upper portion of a plant that is grafted onto another plant part is called a scion. The bottom part or the portion grafted onto is called a root stock. Grafting is used to perpetuate varieties which cannot be reproduced by other means. It is used commonly with fruit trees, roses, and hybrid lilacs. Grafting is a highly technical operation, and because of the complexity this is not the place to go into the subject in depth. Please refer to the publications list at the back of the pamphlet dealing with this subject.

5. Crown Division

This is a relatively simple method of propagation used for herbaceous perennials and certain woody plant material. It is relatively inefficient as only a modest increase in the number of plants is achieved by this method. Herbaceous perennials that bloom in the spring and summer should be divided in the fall. Those that bloom in the summer and fall should be divided in the spring. Many need to be divided as often as every two to three years to prevent overcrowding.

To divide the crown of a plant, the plants must be dug and divided into sections with a sharp knife. With woody shrubs the division may need to be done with a shovel or hatchet.

Dividing should be done while the plant is dormant. The top should be cut back and the roots trimmed at the time of dividing and each section planted as a new shrub.

NURSERY SITE DEVELOPMENT

A number of distinctly different operations take place in propagating nursery. Facilities for each area of activity have to be fitted into the nursery site for optimum efficiency of the total operation.

The following facilities are usually part of a nursery site:

1. Permanent site improvements: windbreaks, roads, an irrigation pond, and an irrigation system.
2. Plant propagating facilities: seedbed area, coldframes, heeling-in grounds, transplant fields.
3. Structural facilities: residence, machine shop, shipping barn, indoor storage (rootcellar), lathhouse.
4. Marketing facilities: sign, sales lot.

PERMANENT SITE IMPROVEMENTS

Nursery grounds have to be well protected from the north and the west, since the prevailing winds are from these directions. A two-to-four-row windbreak, which preferably includes a row of evergreens, planted along the west and north perimeter of the nursery site is a must for areas where wind protection from native trees is absent. If the nursery is larger than 150 m square it is advisable to subdivide the site into equal parts by planting one or more hedges. Suitable hedge plants are caragana, lilac, honeysuckle, or hawthorn. Since planting these windbreaks determines the land-use pattern in the nursery site, much thought should be given to such a subdivision. Preferably the resulting fields should be rectangular, not smaller than 2 acres and not larger than 10 acres. Fields should be identified with a number, symbol, or name for ease of administration.

A convenient road system should serve the fields. One main access road should connect all fields with the buildings listed above. Such a road should be ditched, allow for two-way traffic and be passible under all weather conditions. Small feeder roads of a less permanent nature will then lead into the propagation fields.

The need for an irrigation system and the perfection of such a system will depend on the type of nursery and the location of the nursery. Nurseries located in southeastern Alberta (from Red Deer south) will likely need additional moisture over the normal precipitation since southeastern Alberta is dryer and hotter than central Alberta. Nurseries concentrating on growing their own plants from seeds and cuttings are in greater need of irrigation than nurseries which buy "liner stock". Tree farms require only a minimal outlay for irrigation since additional water is only required at time of transplanting.

The simplest irrigation system is a portable tank. Several tree farms manage their watering needs in this manner. The trees are watered individually by driving along the rows and applying the moisture as required. Usually the greatest need for moisture is at the time of transplanting and with established trees, particularly evergreens, in the fall before freeze up.

Seedbed areas and cuttings require sprinkler irrigation at critical periods e.g. during germination and root formation. Sprinkler irrigation is only feasible if a large supply of water is available from natural sources (a river or a lake) or if such a source can be created artifically. It is beyond the scope of this information booklet to enlarge further on the construction of water storage facilities.

Transportation of water from a pond to the propagating area is usually done with portable aluminum pipe; these pipe sections can quickly be coupled together to form a continuous pipeline. Sprinkler heads of various sizes can be mounted on the pipe and the water pressure developed by the pumping unit activates the sprinkler heads. Water transportation is only applied over large areas in well-established nurseries or those where a substantial

investment has been made. The small nursery operator should concentrate on having sprinkler irrigation available for the seedbed and the coldframe areas.

Further assistance is available from: Irrigation Division, Alberta Agriculture, Lethbridge, Alberta.

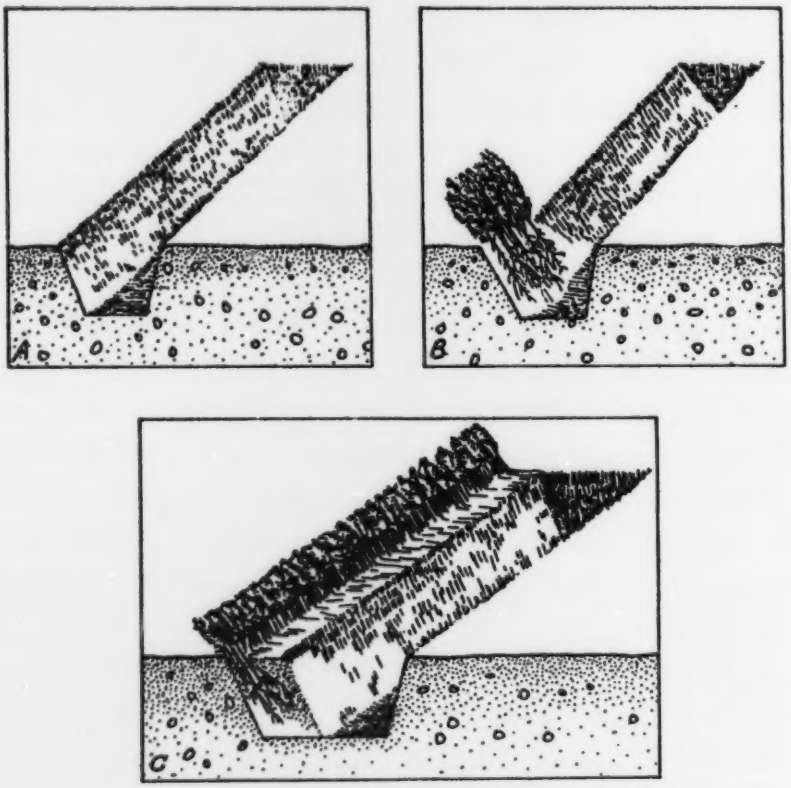
PLANT PROPAGATING FACILITIES

The seedbed and coldframe areas are relatively small compared with the transplant fields. Seedbeds and coldframes are preferably placed on the best available soil, free of weeds and well protected from the prevailing winds. As indicated before, irrigation water should be available for seedbeds and newly planted cuttings.

Seedbed density will determine the carrying capacity or number of seedlings. Production of seedlings suitable for field planting is 40-60 per square foot of seedbed, using broadcast seeding practices. Cuttings are usually planted 2-4 cm apart in rows 20-40 cm apart. Allow at least half the total area for roads and paths.

Coldframes lengthen the growing season, allow higher soil temperatures often needed for quick germination, and give seedlings added protection. Seeds from woody ornamentals often show delayed germination due to seed dormancy; Therefore seedbed protection for long periods (up to one growing season) is advisable.

"Heeling in" is a form of temporary storage for nursery stock. Such outside storage is preferably done in an area close to the structural facilities. The soil of this area should be light in texture. Heavy clay soils can be improved by mixing in peat or sand. If heeling-in grounds are used during the winter a protective snowcover will help to keep the plants vigorous.



The transplant fields make up the major portion of the nursery area. It is important that the exact dimensions of these fields are known, in order to know the carrying capacity for plant materials. Identification of the fields with a number or sign is desirable, particularly if the number of fields becomes larger. New staff will much easier orientate themselves and confusion might be prevented.

STRUCTURAL FACILITIES

The usual pattern of development of a nursery appears to be that the structural facilities are located close to the residence. This is a logical choice with regard to utilities (water, sewer, electricity,

and natural gas) since these usually are available at this site. Such an arrangement also minimizes travel distances between these areas of activity.

Cultural practices demand a variety of implements varying from hand tools to machine-operated equipment. The maintenance and storage of such equipment requires a garage or machine shop. Depending on the type and size of nursery such a machine shop may be simple or complex. Reliable machinery maintenance and repair is essential for a smooth running operation.

Nurseries which get involved in large volume shipping of plant material require a building which is usually given the name of shipping barn. This structure is needed for temporary storage of plant material and for assembling shipments (grading, wrapping, labelling). Since bulky material consisting of live plants is handled, the shipping barn should provide a suitable work area. Therefore a shipping barn should be roomy, cool, and located close to the heeling-in grounds.

Storing plant material indoors greatly increases the flexibility of the operation. In a small scale nursery it might be desirable to have a reliable, inexpensive, indoor storage facility available. The small rootcellar illustrated on page 39 is a good example of what can be constructed. Such rootcellars are suitable for storing vegetables as well as deciduous plants during the winter, provided temperatures range between $0^{o}C$ to $+2^{o}C$ and relative humidity is in the range of 90%.

A "lathhouse" is a simple structure erected to provide shelter and shade for plants. Usually the walls of a lathhouse are made from snowfence. The framework can be sturdy dimensional lumber or steel pipe or any similar material. The function of the roof is only to provide shade. This can be done with a material such as burlap or "saran cloth" (a plastic material, especially manufactured as a shade cloth).

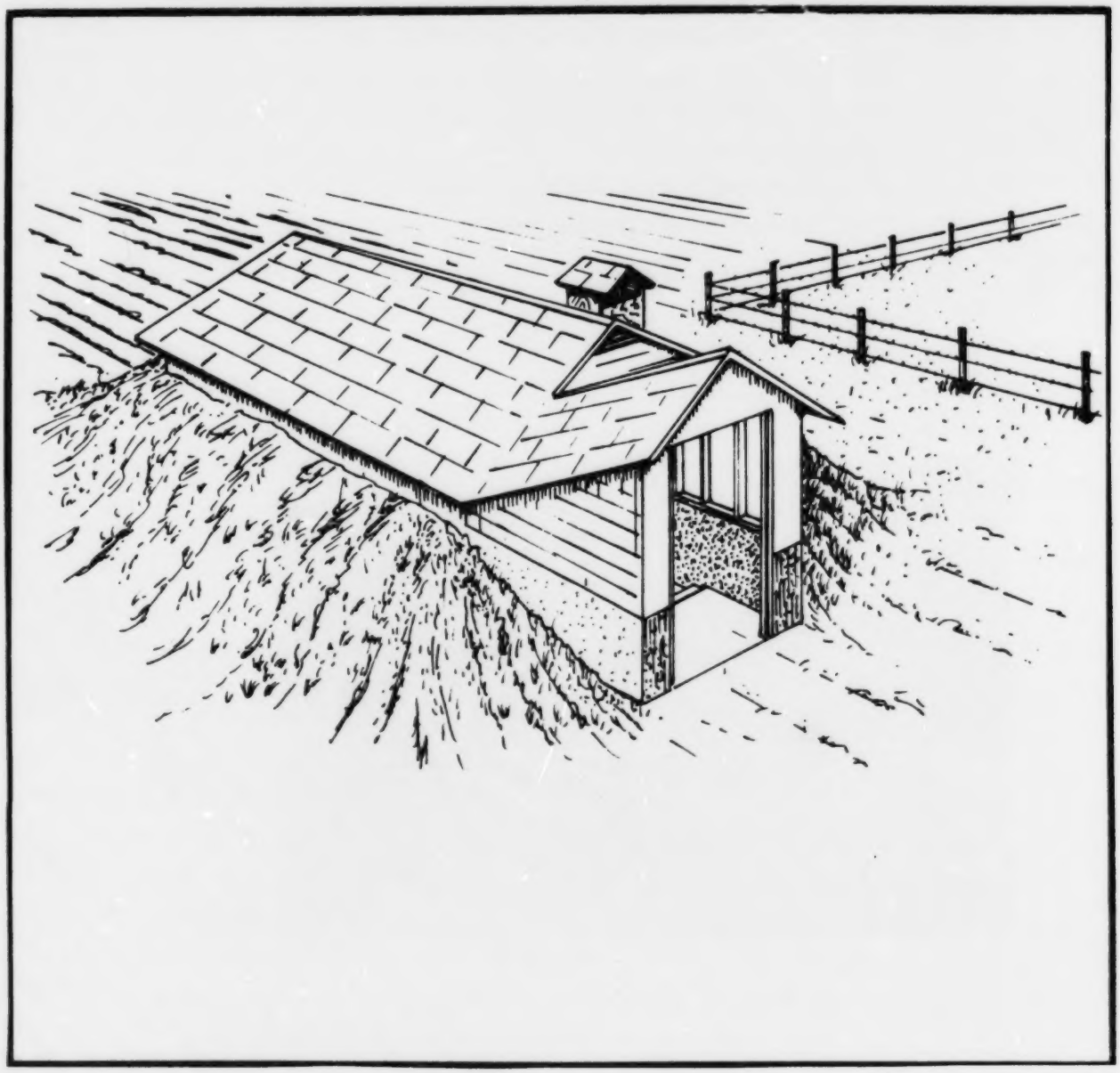
MARKETING FACILITIES

The objective of all nurseries is to sell plant material. A tree farm requires no sales lot since the finished product is moved directly from the growing site (the nursery) to the customer. Similarly a nursery which wholesales all its plants does not require a sales lot.

However, nurseries concentrating on retail sales require the development of a sales lot where the merchandise is stored and exhibited. A lath house is often combined with a sales lot. Provision for parking and directional signs as well as a business sign are all part of a sales lot.

A nursery outlet, where the plant material is offered for sale in containers. Note the "lath house" in the background.

SMALL ROOTCELLAR



GROWING SEEDLINGS IN THE NURSERY

SOIL PREPARATION

The actual rearing of the seedlings in your nursery begins with soil preparation.

Tillage should be to a depth of 15-20 cm followed by discing of the first 10 cm. Immediately prior to seeding the soil should be rotovated to a depth of 10 cm then harrowed in 2 directions for levelling.

Soil testing should be carried out so fertilizers can be applied prior to seeding and the fertilizer incorporated into the soil.

If the soil you are working with has a very high clay content or the land is very flat, causing drainage problems, molding seedbeds so that they are slightly elevated improves the drainage and subsequent seedling survival. This is usually done with an attachment for a 3-point hitch or by using boards. Using boards is very time consuming.

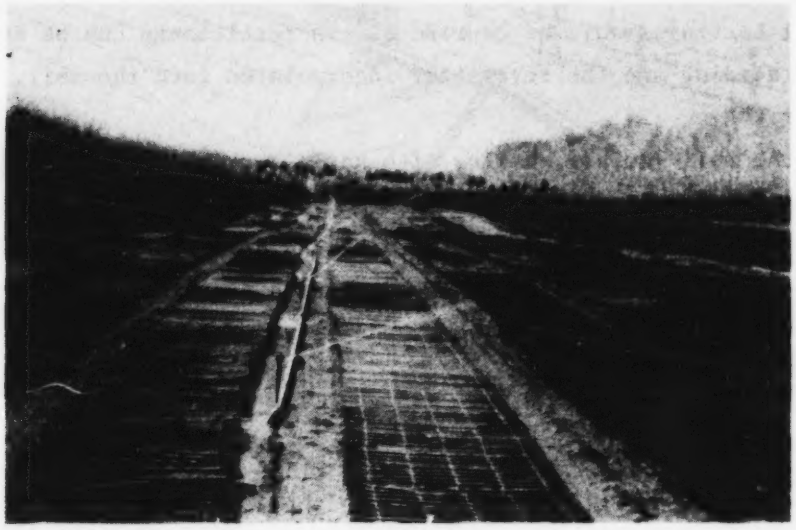
SEEDING

Seeding is generally carried out in the fall to take advantage of early spring moisture and to permit overwinter stratification of the seed. Certain species, such as roses, cherries and hawthorns require artifical stratification regardless of season of sowing. Stratification requirements are listed in the appendix.

Unstratified oval or round seed can be machine seeded. These machines seed at a rate set on the machine, cover, and tamp the seed. Stratified seed, which is moist and generally mixed with peat, or seed with large wings such as maple and ash must be hand seeded into furrows which can be made by hand or machine.

Depth of seeding is 2½ times the diameter of the seed. After seeding, cover the seedbeds with a layer of sand to aid in preventing damping-off when the seedlings begin to germinate.

Shading the seedbeds after seeding by covering with a snowfence will promote better survival of germinating seedlings the following year. These snowfences are most useful on coniferous stock which grows slowly and will not grow past the snowfence in the first year. Deciduous seedlings grow fairly rapidly and the snowfence will have to be removed within a month after germination. The snowfence shades and protects seedlings from surface soil movement which can girdle growing seedlings.



Shade conifer seedbeds in the first year to prevent rapid drying and temperature fluctuations. Note the sprinkler irrigation.

IRRIGATION

Irrigation requirements change with seedling development. At germination the rooting zone of the seedling is very shallow, requiring that water be applied frequently since this surface area dries out rapidly. Allowing this zone to dry would lead to seedling mortality.

As seedlings develop and extend their root systems the rooting zone increases and dries out more slowly so waterings can be less frequent but will need to be more intense to allow the irrigation water to penetrate.

Frequent light waterings for older seedlings are detrimental as they promote a shallow, poorly developed root system.

The propagation of cuttings in the field requires the use of large amounts of water after planting to help the cutting to root. Once rooting has occurred watering frequency can be reduced to that used on other seedlings.

Watering should be reduced after flushing has stopped. Continued application of water will cause the seedling to remain succulent, prevent hardening off of the wood and create winter-kill problems.

On the other hand, heavy watering prior to freeze-up is necessary to ensure soil moisture levels are sufficiently high to prevent frost heaving of the seedlings and to give the seedlings a good start in the spring.

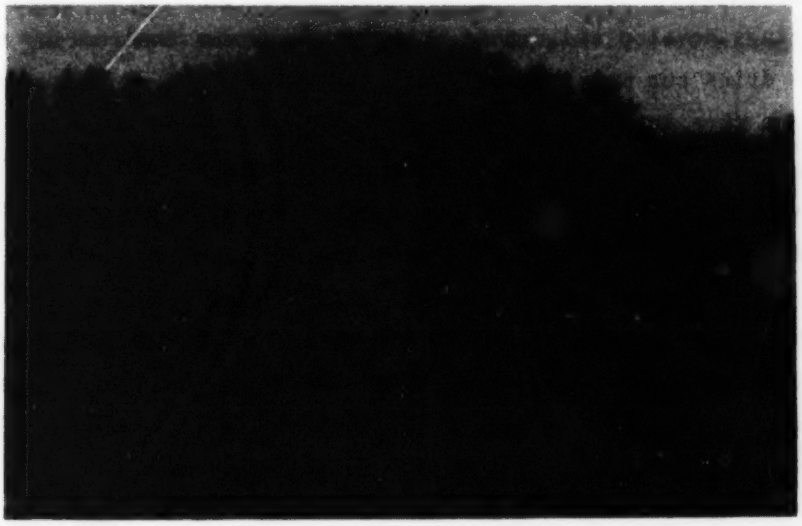
Watering seedlings older than one year should be limited to that required to promote normal growth.

FERTILIZATION

Once the crop is established soil samples should be taken annually to enable you to make proper fertilizer additions. The Soil and Feed Testing Lab can analyse soils and make fertilizer recommendations.

When adding fertilizer as a top dressing be sure that the foliage is brushed to knock any fertilizer off. Irrigation is necessary following application to incorporate the fertilizer and distribute the nutrients and to prevent localized burning of the seedlings.

Soil testing and adding of fertilizer is usually carried out in the spring.



Seedbeds of 2-year-old deciduous stock.

Seedbeds, maximum production from limited area, in this case green ash at 175 seedlings per square metre.

WEED CONTROL

Weeds can seriously reduce the growth and survival of seedlings thus reducing the profitability of a nursery operation. Weeds rob seedlings of nutrients, water, and sunlight.

Manual weed control is the most effective method. This method is, however, costly in terms of time involved. The larger the operation the more important other methods of weed control become.

Mechanical weed control in the planted rows can be done with specially designed cultivators either self-propelled or mounted on tractors.

Chemical weed control is best used on ungerminated seeds or dormant seedlings. A contact herbicide can be used to remove weeds prior to germination of the seeds, while for dormant material there is a wide variety of chemicals available.

Weed control begins with planning the rotations in your fields or field. Continuous cropping leads to a buildup of perennial weeds which become very difficult to eliminate. To prevent this a fallow period of 2 years following a nursery crop is advisable to enable you to eradicate these weeds using chemicals and cultivation. The fallow period also allows you time to make other soil or physical improvements.

TOP AND ROOT PRUNING

Top and root pruning are carried out to better prepare a seedling for transplanting.

Horizontal and lateral root pruning should be carried out in July of the second year of growth. Top pruning should also be carried out at this time.

Root pruning provides the seedling with a denser more compact root system so less of the root system is lost at harvesting and therefore transplanting is much easier.

Top pruning is done to reduce a seedling to a more manageable size for harvesting.

July is the time for pruning. This allows the plant to flush normally before pruning and any new root or top growth can develop sufficiently before winter.

PEST CONTROL

The high concentration of succulent plant material provides an ideal place for insect or disease pests to do substantial damage. Frequent inspection of the seedlings will disclose pests so immediate action can be taken to correct the problem.

Damping off can be a problem with germinating seedlings, high seedling densities resulting in high humidity around the seedlings favor the development of this disease. It is not a problem in nurseries in this area.

Insecticides such as Malathion will control most insect pests which create problems.

Animal pests such as mice can be a problem by girdling seedlings or eating seed before it gets a chance to germinate. Poison baits are the most effective method of control, however extreme care is urged when using these poisons.

HARVESTING

The scale of operation will determine season and method of harvesting. If all stock can be moved in the short time from thaw until flushing in the spring this is the time to do it. This will eliminate the need for

overwinter storage facilities. If harvesting cannot be completed in the spring then either complete or partial fall harvesting must be used. This entails the need for some sort of overwinter storage.

Heeling-in involves storage outside in a field. Seedlings are harvested, graded, then placed in a furrow in the soil with the roots covered with soil. This method is inexpensive, however, you must still wait for the ground to thaw in the spring before the seedlings are usable.

Cold storage facilities in the form of a large cooler or rootcellar are ideal. The main criterion is to have temperatures at $0^{o}C$. Cooler temperatures are not harmful although alternate freezing and thawing is not good. This type of facility requires a large capital outlay, however it enables you to bring plants out earlier to begin packing orders prior to the spring thaw.

The above facilities can be used singly or in conjunction with one another depending on needs.

Field harvesting itself varies from a completely hand operation to being fully mechanized. Hand lifting involves undercutting the seedlings at the desired depth then pulling by hand. Undercutting is done using an undercutter mounted on a tractor's 3 point hitch. When hand lifting grab a cluster of seedlings rather than a single one and shake the soil out of the roots. Banging the seedlings on the ground injures the roots.

The seedlings must not dry out between the digging and grading area. Covering them with tarps and giving them a water spray before transit will ensure they do not dry out.

Nursery stock should be shipped with roots wrapped in moist peat and sealed in plastic. If transport is required by commercial carrier wrap the tops in a breatheable protective cover. Shipment must occur quickly after wrapping to prevent molding or rooting of the plants.

TRANSPLANTING

Transplanting seedlings from seedbeds is necessary to grow them to a size larger than that which is possible in the seedbed. The distance apart that they are transplanted depends on the final size and shape of tree desired.

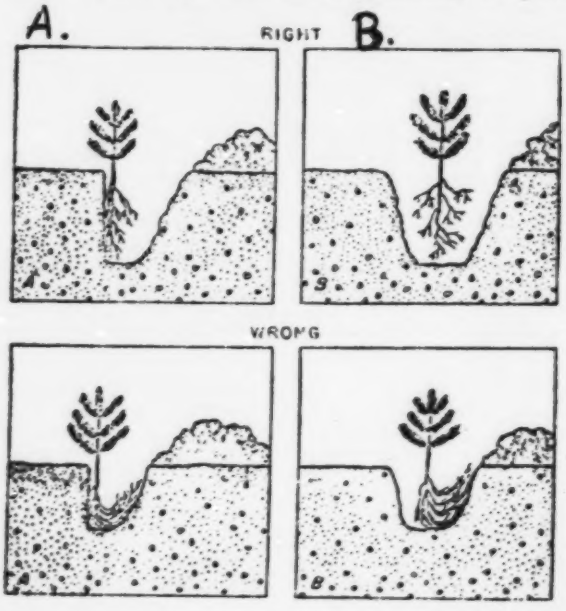
Spring is the best season for transplanting deciduous species while conifers can be done in spring or early fall.

Transplanted stock should be watered heavily immediately after planting. This helps to remove air from around the roots and provides them with easy access to water to help them get established. This is important since seedlings lose a large portion of their root system, especially the fine water absorbing roots, when harvested for transplanting. Watering should be continued well into summer on newly transplanted stock then reduced to the amount required to prevent excessive drying of the soil in late summer and fall.

Transplanting Colorado spruce seedlings from concentrated seedbeds or containers to wider spacing, in this case 8-10 cm apart in 46 cm rows.

If you use containers for transplanting seedlings, watering is harder to regulate. The reason for this is that the plug of soil containing the seedling roots is generally of a lighter texture than the surrounding soil; as a result it will tend to dry out more quickly than the soil. This can mean having a dry plug even though the soil is still moist. If not watched carefully you may end up with a dead seedling even though soil moisture appears adequate.

Small container growing is used in large nursery operations to start many seedlings for transplanting or potting up later.



Right and wrong methods of hole transplanting:
A - Side-hole method
B - Centre-hole method

EQUIPMENT

Nursery equipment comes in several types and price ranges. To determine your specific needs analyse the jobs that need doing, visit other nurseries to evaluate various alternatives, then settle on the system you want to use.

A catalogue of nursery equipment is available from U.S.D.A. Forest Service, Equipment Development Center, Missoula, Montana, U.S.A. 59801.

SHIPPING AND MARKETING NURSERY STOCK

Marketing nursery stock can be nearly as much work as producing it. Marketing can be very complex, costly, and time consuming. The process actually starts with the consumer who creates a demand for the product. The nursery operator must be able to supply the trees and shrubs that are in demand. This is not to say however, that the consumer is not open to new products and ideas.

There are basically two channels for marketing: wholesale and retail.

A. WHOLESALE

Wholesale selling involves selling to other nursery stock outlets and garden centres, landscapers, or construction companies. Wholesale marketing deals mainly with the relatively large orders and generally lower prices than direct-to-consumer marketing.

B. RETAIL

Retail sales are those where the plant material is sold directly to the consumer, who will plant them or have them planted. There are three main ways to retail nursery stock: 1) retail sales lot or garden centre, 2) mail order nursery, 3) landscape nursery.

1. Retail Sales Lot or Garden Centre

When retailing nursery stock in this manner extensive thought must be put into the location of the nursery. To be successful retail outlets should be located fairly near to large centres of population. The more accessible your establishment is the greater volume of business you can expect. There must be a demand in the area for the products you intend to market. A great deal of effort should be put into examining the possibilities of a successful operation in the area where you wish to locate.

A sales lot must be functional. It is very important to landscape your sales area. This gives the customer a favorable impression and also enables him to see some of the plant material growing in a pleasant setting. The sales lot must be kept neat and attractive.

Knowledgable and friendly staff should be employed on the sales lot. Customers will have many questions about choosing and caring for plant material and it is important to have competent help on hand. Familiarity with the principles and practices of landscape design and plant growth is necessary.

2. Mail Order Nurseries

This type of nursery does most of its business through the mail. They have an advantage in that their location need not be central to any large population area. Mail order nurseries are also able to offer the customer a much wider assortment of plants because they do not have to display their entire stock.

One of the most important factors in a successful mail order nursery is the catalogue. It must be attractive, well written and accurate. The cost of printing and distributing such a catalogue can be quite high.

The acquisition of a mailing list for distribution of the catalogue is one of the first steps in beginning a mail order nursery. About the only way to build this mailing list is with an extensive advertising campaign, and such campaigns are costly. The mailing list may be the most valuable asset of a mail order nursery. Much time and effort should be devoted to the building of this list.

Orders must be processed and filled accurately. Shipping should be done through the most efficient system, whether it be parcel post, express or freight. Plant material must be packed well and should

arrive at its destination in good condition. A list of the contents should be included in the package and instructions for planting and care.

3. Landscape Nurseries

These are businesses that derive a major portion of their income from landscaping jobs. It is a distinct type of business which is often tied in with the production nursery. Like the sales lot and garden centre, choosing a location for a landscape nursery is very important. These operations must be near to a fairly large population centre. A new and developing residential area for example would be a good location for a landscape nursery. The actual site choosen is not as important as with the garden centre, for in general you will go to the customer to make your contacts rather than the other way around. This type of business can be started on a fairly small scale with the initial landscape projects being planted with stock purchased from other nurseries. You can gradually acquire the equipment necessary for a full-scale operation and begin growing your own stock. Customers of a landscape nursery might include homeowners, small businesses, and industries and factories, schools and hopsitals. Homeowners usually constitute the most important group for the average landscape nurserymen. Anyone starting a landscape nursery should be very familiar with the principles of landscape design. There is much written on the subject and many courses offered through schools and universities. Every attempt should be made to become as knowledgeable as possible on the subject and to keep abreast of new developments and trends in the industry.

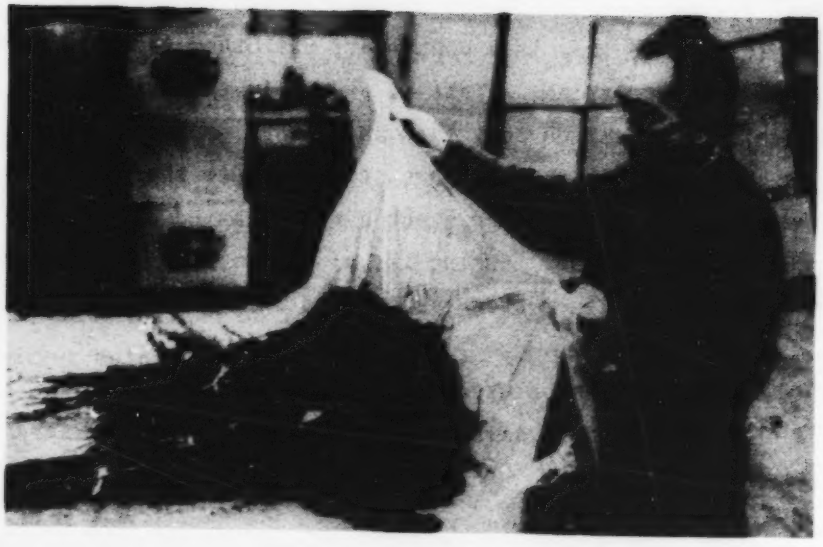
MARKETING FORM

Nursery stock can be marketed in several different forms: bare root, container stock, balled and burlapped, or as mature trees transplanted by a tree mover.

A. BARE-ROOT STOCK

This is an inexpensive way of marketing and the easiest to handle if material is being shipped. Bare-root trees and shrubs are marketed with no soil on their roots. They are normally packed in a material such as peat moss to keep the roots from drying out.

An example of "bare-root" stock, bundled in certain quantities.



Wrapping of "bare-root" stock, using damp peat moss

To market bare-root stock it is important to sell the plant material before any new growth flushes. This means it should be sold in the early spring while still dormant. The plant material should be wrapped well to prevent drying out of the roots. An ideal wrap for the bare root plants is moist peat moss, polyethlene film (2 mil) as a moisture-proof inner wrap, and burlap for a sturdy outer wrap. The plants can be bundled together or wrapped individually. Two points must be stressed: the roots should not be allowed to dry out, and the plant should be sold and planted before active growth begins.

B. CONTAINER STOCK

There are actually two kinds of plants sold in containers. One type has spent its entire life in a container; the other is field grown and then planted in a container. This is generally the method used with plant material sold in retail nursery lots and garden centres. Time of planting is not as critical as with bare-root stock because there is less root disturbance. Healthy container stock can be planted at virtually any time during the growing season. Spring is, of course, preferable. More care must be taken if container stock is planted in the summer or fall.

Many containers can be used, ranging from one gallon cans to bushel baskets. There are many available commercially through nursery supply companies.

Where land has a high value large pot growing may serve you better. These plants will be grown to large landscape sizes.

C. BALLED AND BURLAP MATERIAL

This is the normal method (along with container stock) for marketing evergreens. The plants are dug with a ball of soil around their roots. This soil ball is wrapped in burlap to protect the roots and facilitate handling.

D. MATURE TREES

Mature trees are usually moved with a tree spade. Tree spades are machines that will transplant trees mechanically. This service can be provided by the nursery or by the purchaser. Tree spades are available in a range of sizes. For example, one company produces tree spades that will move a small tree or shrub with a trunk diameter up to 3 inches, the soil ball 30 inches in diameter and 36 inches deep, as well as a large unit that will move a tree with a 6 inch diameter trunk and a soil ball 66 inches in diameter and 60 inches deep. If one intends to have a tree farm and market mainly large trees it may be worth while to purchase a tree spade.

A tree farm which specializes in producing large specimens. These trees are intended to be moved with a tree spade.

ADVERTISING

Advertising and promotion are important facets of any business offering a product or service. Advertising can be as simple as an attractive sales lot and sign or as comprehensive as paid advertisements in the mass media. It is important to aim the advertising at the people who are likely to be customers. For example, in selling wholesale, the

advertisement should appear in trade journals that other nursery operators will read. If the stock is to be sold at a retail level, advertising should be done on radio, television or in newspapers. The importance of an attractive and informative catalogue was stressed in the discussion on mail order nurseries. Having a catalogue that the customer can browse through at home without spending too much time at the nursery is helpful. The catalogue is also an excellent means of advertising.

Obtaining professional advice when conducting an advertising campaign is an extra cost, but may be well worth the expense.

An attractive sign, which clearly describes the business is a great asset to the nursery.

FURTHER INFORMATION

The information provided in this pamphlet is intended to provide only a framework for establishing small nursery. As with most enterprises experience is the best teacher.

Correspondence courses in Nursery Management are available from Ontario Agricultural College, University of Guelph, Guelph, Ontario, N1G 2W1.

Knowledge can also be acquired through study of the literature listed at the back of this pamphlet.

Information can be gained by contacting the Alberta Nursery Trades Association at the following address:

Red Deer & North Chapter: R.R. 6, Site 3, Box 5, Edmonton, Alberta

South Chapter: 2626 - 48 St. S.E., Calgary, Alberta, T2B 1M4

LICENSING

Except for the licensing of vendors required by some municipalities, there are no regulations concerning the growing and sale of nursery stock in Alberta. The sale of woody plant material within the province is not governed by any legislation. If nursery stock is, however, imported from outside Canada, import permits are controlled by the Federal Plant Quarantine Act, Plant Protection Division, Agriculture Canada.

SEED AND LINER STOCK SOURCES

Seed and liner stock is available from commercial seed houses and nurseries. To obtain names and addresses of these firms consult the trade journals listed in the publications list.

The Alberta Tree Nursery of Alberta Agriculture also offers seed for sale. A list of the species, quantities and prices of the available seed is attached. Liner stock is offered for sale for farm woodlot development and the establishment of Christmas tree farms. For more information contact the Alberta Tree Nursery and Horticulture Centre, Alberta Agriculture, RR 6, Edmonton, Alberta T5B 4K3.

The nursery business in Alberta is a rapidly growing, healthy industry. With increasing concern for the environment and desire to beautify our surroundings there will be a continued and increasing demand for nursery stock from both the homeowner and businesses. With proper planning and management a nursery can develop into a profitable and satisfying business.

LIST OF TREE SEEDS AVAILABLE FROM THE
ALBERTA DEPARTMENT OF AGRICULTURE
PROVINCIAL TREE NURSERY

Tree Variety	Quantity	Price
White spruce	200 gm	$10.00
Colorado spruce	200 gm	10.00
Lodgepole pine	200 gm	7.50
Siberian larch	200 gm	17.50
Mayday	200 gm	7.50
Green ash	400 gm	12.50
American elm	400 gm	12.50

TABLE I TREE AND SHRUB SEEDS REQUIRING STRATIFICATION

SPECIES	MONTHS (M) TREATMENT - STRATIFICATION MEDIUM
Chokecherry	5 M - peat
Black ash	9 M - peat
Green ash	2 M - wet (Spring)
Basswood	6 M - peat
Buckthorn	3 M - wet
Buffaloberry	3 M - wet
Dogwood	3M - wet
Douglas fir	1-2 M - wet
Hawthorn	5 M - peat
Cranberry	3-4 M - peat
Honeysuckle	1-2 M - wet (springs)
Black cherry	5 M - peat
Cherry prinsepia	5 M - peat
Mongolian cherry	5 M - peat
Nanking cherry	5 M - peat
Korean bush cherry	5 M - peat
Dropmore cherry	5 M - peat
Sandcherry	5 M - peat
Juniper Rocky Mtn.	5 M - peat
Juniper creeping	5 M - peat
Siberian larch	1 M - wet (spring)
Lilac common	2 M - wet (spring)
Villosa lilac	2 M - wet (spring)
Japanese Lilac	2 M - wet (spring)
Manitoba maple	3 M - wet (spring)
Mayday	5 M - peat
Bur oak	Fall seeding only
Ohio buckeye	4 M - wet
Russian olive	2 M - wet
Pincherry	5 M - peat

SPECIES	MONTHS (M) TREATMENT - STRATIFICATION MEDIUM
Ponderosa pine	1 M - wet
Rosa sp.	5 M - peat
Saskatoon	5 M - peat
Snowberry	5 M - peat
Wolf willow	2 M - wet
Hazelnut	3 M - wet
Balsam fir	1 M - wet
Swiss stone pine	3 M - wet

M - Month

TABLE II GERMINATION DATA

SPECIES	GERM. TEMP. Night	LIGHT FOR GERM. Yes	No	TIME TO GERM. Days	SEEDS/kg
Abies balsamea		x		20	131,000
Picea glauca			x	10	485,000
Picea pungens			x	10	220,000
Pinus cembra			x	28	4,400
Pinus contorta			x	10	351,000
Pinus sylvestris			x	10	243,000
Pseudotsuga menziesii			x	10	95,000
Pinus mugo pumilio		x		14	154,500
Juniperus scopulorum			x	15	61,500
Euonymus nana			x	60	N/A
* Acer negundo			x	18	30,800
Aesculus glabra			x	30	155
* Betula papyrifera		x		40	11,000,000
Crataegus			x	30	cerronis 44,000 succulenta 39,700
* Elaeagnus angustifolia			x	25	15,000
* Fraxinus			x	20	nigra 15,500 pennsylvanica 39,700 ornus 36,000
* Larix			x	20	sibirica 88,500 occidentalis 150,000 laricina 179,000
* Prunus padus			x	30	19,700
Prunus pennsylvanica			x	60	22,000
* Prunus virginiana			x	21	13,200
* Quercus			x	42	macrocarpa 485
Sorbus			x	14	americana 35,200
Acer ginnala			x	38	39,700
Amelanchier			x	70	alnifolia 243,000
* Caragana			x	20	arborescens 39,700
* Cornus			x	24	stolonifera 37,500

SPECIES	GERM.	TEMP. Night	LIGHT FOR GERM. Yes	No	TIME TO GERM. Days	SEEDS/kg
Cotoneaster	86	68		x	100	acutifolia 53,200 lucida 51,800
* Hippophae rhamnoides				x	45	110,000
* Lonicera				x	24	tatarica 331,000
Prinsepia				x	30	sinensis 4,400
Prunus besseyi				x	60	6,000
Prunus tomentosa				x	60	10,000
Prunus japonica				x	60	4,600
Rosa altaica				x	30	114,500
Sambucus				x		canadensis 232,000
* Shepherdia argentea				x	24	110,000
* Syringa				x	36	vulgaris 154,500 villosa 119,000 japonica 117,000
Viburnum trilobum				x	30	29,900
V. lentago				x	120	13,000

* See note 2

Note: 1. Germination time is that expected after proper stratification procedures have been followed.

2. Data on other species has been gathered from "Seeds of Woody Plants of U.S.". Germination temperature and light requirements obtained solely from that book. *Time to germinate data obtained from Provincial Tree Nursery. Information on the number of seeds/kg was obtained from the Provincial Tree Nursery, Oliver.

LIST OF PUBLICATIONS

Alberta Horticultural Guide. Alberta Agriculture Publications Office, 9718 - 107 Street, Edmonton, Alberta T3K 2C8.

Beginning in the Nursery Business, by John J. Pirrey, American Nurseryman, 343 South Dearborn Street, Chicago, Ill. 60604, U.S.A.

Insect Pests of Alberta, by Hugh G. Philip. University of Alberta Bookstore students union Building, Edmonton, Alberta, T6G 2G4

Tree and Shrub Diseases and their Control. Alberta Agriculture Publications Office, 9718 - 107 Street, Edmonton, Alberta T5K 2C8.

Woody Ornamentals for the Prairie Provinces, R. H. Knowles. Faculty of Agriculture and Forestry, University of Alberta, Edmonton, Alberta Bulletin #58.

Woody Plant Source List, T. J. Cole and L. C. Sherk, Information Division, Canada Department of Agriculture, Ottawa, Ontario K1A 0C7.

Guide Specification for Nursery Stock, Canadian Nursery Trades Association, 3140 Littlejohn La. Cooksville, Ontario

Chemical Weed Control in Shelterbelts. Information Division, Canada Department of Agriculture, Ottawa, Ontario K1A 0C7 Publication 1511.

Forest Tree Nursery Soil Management, K. A. Armson and V. Sadreiko. Ministry of Natural Resources, Division of Forests, Forest Management Branch, Toronto, Ontario M7A 1W3

How to Grow Seedlings of Trees and Shrubs, F. W. Schumacher, F. W. Schumacher Co., Horticulturists, Sandwich, Mass. 02563, U.S.A.

Conifer Nursery Practice in the Prairie Plains, U.S. Department of Agriculture, Forest Service, Washington D.C. 20250, U.S.A. Handbook #279.

A Directory of Forest Tree Nurseries in the United States, U.S. Department of Agriculture, Forest Service, Washington, D.C. 20250, U.S.A.

Native Trees of Canada, R.C. Hosie, Canadian Forestry Service, Mall Centre Building, 499 Portage Avenue, Winnipeg, Manitoba.

Trees and Shrubs for the Northern Plains, D.G. Hoag, North Dakota Institute for Regional Studies, Fargo, North Dakota, U.S.A.

Woody Seed Plant Manual, U.S. Department of Agriculture, Forest Service, Washington, D.C. 20250, U.S.A. Miscellaneous Publication #654

Plant Propagation: Principles and Practices, H. T. Hartmann and Dale E. Kester, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, U.S.A.

Catalogue and Common Names of Woody Ornamentals, R. H. Vick, Friends of the Botanic Garden of the University of Alberta, Department of Botany, The University of Alberta, Edmonton, Alberta. Publication #5.

Trade Journals

Landscape Canada, The Canadian Nursery Trades Association, 1568 Carling Avenue, Ottawa, Ontario K1Z 7M5

The American Nurseryman, The American Nurseryman Publishing Company, 310 South Michigan Avenue, Chicago, Illinois 60604, U.S.A.